ANALYSIS AND MODELLING OF ULTRACAPACITOR

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Dedicated to my beloved parents

Rai bin Ngah Mat Ali & Rohani binti Jusoh

Siblings

Nor Arina binti Rai

Nor Raidah binti Rai

Muhamad Najmi bin Rai

Muhamad Hisyam bin Rai

and

All my friends in MEP programme

for their support and encouragement

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ABSTRACT

Ultracapacitor is one of most popular device for energy storage system because of it capability that have high charge/discharge efficiency, can operate at high current, have long life cycle and no chemical reaction involve in store and release of energy. Ultracapacitor modelling is important for the electrical system analysis and equipment design. An efficient and high accuracy model can help electrical engineers thoroughly understand ultracapacitor's characteristics. A commercial ultracapacitor cell is characterized under standard procedures to assess its performance. This project focuses on the analysis and modelling of ultracapacitor cell characteristic. Two experiments involve which are charging/discharging test and AC Impedance test. The charge / discharge test is to determine ultracapacitor cell ability on charge and discharge performance. AC impedance test/ Electrochemical impedance spectroscopy (EIS) is to measure the complex impedance of ultracapacitor. The purpose of the test is to determine capacitance and equivalent series resistance. Based on experiment result, parameters and analysis, the equivalent circuit model of ultracapacitor is proposed. After that, the proposed model is simulated with MATLAB/Simulink and EIS Spectrum Analyser for verification. Then, the simulation result carried out is analysed and compared with experiment results. Based on ultracapacitor characteristic, the electrical circuit modelling was present in this thesis and can be used for power electronic, backup memory, heavy transportation application, hybrid electric vehicles and as power back up for UPS application.

ABSTRAK

Ultracapacitor ialah satu daripada peranti paling popular untuk sistem simpanan tenaga disebabkan ia mempunyai keupayaan untuk mengecas/menyahcas pada kecekapan yang tinggi, boleh beroperasi pada arus yang tinggi, mempunyai kitaran umur yang panjang dan tiada tindak balas kimia terlibat dalam penyimpanan dan pembebasan tenaga. Model Ultracapacitor penting untuk analisis sistem elektrik dan reka bentuk peralatan. Kecekapan tinggi dan kejituan model boleh membantu jurutera elektrik memahami sifat ultracapacitor. Sel ultracapacitor komersial akan digunakan untuk ujikaji berdasarkan standart prosedur untuk menilai prestasinya. Projek ini menumpukan kepada analisis dan model sel ultracapacitor. Dua eksperimen terlibat iaitu ujian mengecas/menyahcas dan ujian arus ulang-alik galangan. Ujian mengecas/menyahcas adalah untuk menentukan kebolehan prestasi sel ultracapacitor mengecas/menyahcas. Ujian arus ulang-alik galangan / Elektrokimia Galangan Spektroskopi adalah untuk mengukur nilai kompleks galangan ultaracapacitor. Tujuan ujian ialah adalah untuk menentukan nilai rintangan siri setara dan nilai capcitor. Berdasarkan keputusan eksperimen, parameter dan analisis, model litar elektrik setara ultracapacitor dicadangkan. Selepas itu, model cadangan disimulasikan dengan MATLAB / Simulink and EIS Spectrum Analyser untuk pengesahan. Kemudian, keputusan simulasi yang dijalankan dianalisis dan dibandingkan dengan hasil ujian. Berdasarkan sifat ultracapacitor melalui ujian yang dijalankan, model litar elektrik dicadangan didalam tesis ini dan boleh digunakan untuk alatan elektronik kuasa, aplikasi pengangkutan, kenderaan hibrid elektrik dan aplikasi untuk alat bantuan ingatan.